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(71) Applicant: **Samsung Electronics Co., Ltd.**
Suwon-city, Kyungki-do (KR)

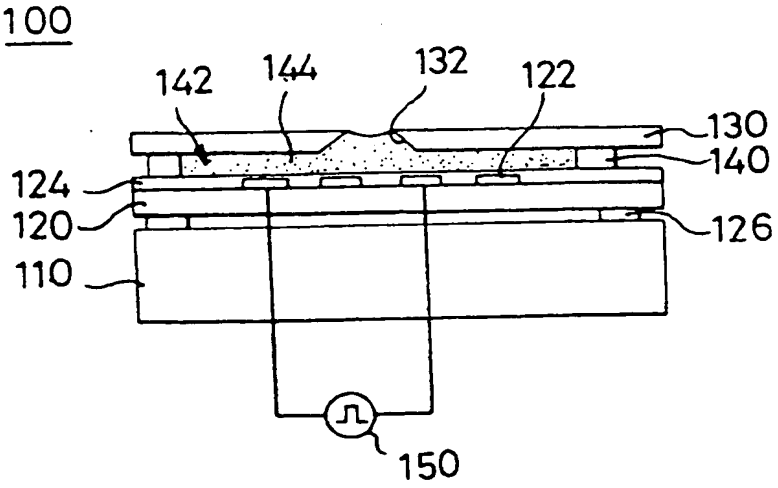
(72) Inventors:
- **Kwon, Oh-keun**
  Kwonsun-gu, Suwon-city, Kyungki-do (KR)
- **Moon, Chang-youl**
  Euwang-city, Kyungki-do (KR)
- **Moon, Jae-ho**
  Songpa-gu, Seoul (KR)

(74) Representative: **Chugg, David John**
Appleyard Lees,
15 Clare Road
Halifax, West Yorkshire HX1 2HY (GB)

(54) Apparatus for jetting ink

(57) An apparatus for jetting ink including a magnet (110), a deformable plate (120) for imposing a pressure upon an ink chamber (144) and coils (122) attached to the deformable plate (120). When an electric signal is applied to the coils (122), the plate (120) is deformed by a magnetic force produced between the magnet (110) and the coils (122). At this time, the ink (142) within the ink chamber (144) is ejected to the outside via a nozzle (132). The quantity and the speed of the ejected ink (142) can be easily controlled while incorporating a simplified structure and a facilitated manufacturing process. Also, printing at a high resolution can be performed at high speed.

FIG. 3



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Description

The present invention relates to an apparatus for jetting ink of an ink-jet print head, and more particularly, to an apparatus for jetting ink by utilizing a magnetic force.

An apparatus for jetting ink applied to conventional drop-on-demand (DOD) ink-jet print heads employs either a heating system which uses a surface heating element or a piezoelectric system which uses a piezoelectric element.

As shown in Figure 1, an apparatus 10 for jetting ink of the heating system is formed such that a lower insulating layer 14, a heating element 16, electrodes 18, an upper insulating layer 20 and a protecting layer 22 are sequentially stacked on a printed circuit board (hereinafter referred to as "PCB") 12. Passage walls 23 are installed between a nozzle plate 24 and the protecting layer 22 to form an ink chamber 26. Then, the ink chamber 26 is connected to a reservoir (not shown), and both electrodes 18 are connected with a driving signal generator 28.

When a driving signal is supplied to the electrodes 18 from the driving signal generator 28, the heating element 16 is heated, and ink 27 within the ink chamber 26 is boiled. At this time, bubbles 29 are produced within the ink chamber 26, and the bubbles 29 push the ink 27 within the ink chamber 26 out of a nozzle 25 of the nozzle plate 24, thereby ejecting an ink jet 30. The ink jet 30 is ejected from the nozzle 25 in accordance with the driving signal, i.e., a print signal.

As shown in Figure 2, an apparatus 40 for jetting ink of a piezoelectric system is provided with a PCB 42, a diaphragm 44, a piezoelectric element 46, a spacer 48 and a nozzle plate 50. An ink chamber 54 is formed by the diaphragm 44, the piezoelectric element 46 and the nozzle plate 50. The interior of the ink chamber 54 is filled with ink 53.

If a driving signal is supplied to the piezoelectric element 46 from a driving signal generator 52, the piezoelectric element 46 mechanically expands and contracts. An ink jet 55 is produced by ejecting the ink 53 within the ink chamber 54 out of the nozzle 51 by the expanding and contracting action of the piezoelectric element 46.

However, the apparatus 10 for jetting ink using the heating system deleteriously requires so much time for generating the bubbles that the ejecting speed of the ink, i.e., the print speed, is slowed down, and the characteristics of the heat emitting body (heating element 16) are liable to be changed in connection with the surrounding temperature. The apparatus 40 for jetting ink using the piezoelectric system has a drawback of incurring high cost due to the use of the high-priced piezoelectric element 46.

Furthermore, both ink-jet apparatuses 10 and 40, using the heating system and the piezoelectric system, respectively, involve a fastidious manufacturing process which thereby degrades the productivity of such apparatus.

On the other hand, U.S. Patent Nos. 4,057,807 and 4,210,920 disclose ink-jet apparatuses for ejecting ink by vibrating a magnetically active diaphragm plate by means of an electromagnet.

The ink-jet apparatuses described in the above Patents Nos. 4,057,807 and 4,210,920 are equipped with a magnet driver attached to the outside of a nozzle of a head and the magnetically active diaphragm plate for sealing an ink chamber. The ink is ejected by a pressure which is exerted when the magnetically active diaphragm plate is deformed by a magnetic field generated by the magnet driver.

However, according to these conventional ink-jet apparatuses, when any one magnet driver coil is magnetized, a secondary current becomes induced to another driver coil nearby. Therefore, the magnetically active diaphragm plate of another driver side is activated to eject the ink from another undesired nozzle.

Therefore, it is difficult to obtain a favourable printing quality. Further, the magnet driver is attached to the outside of the nozzle to make the ink-jet apparatus bulky in its construction.

Accordingly, it is an aim of embodiments of the present invention to provide an apparatus for jetting ink of an ink-jet printer simplified in structure, facilitated in manufacturing and stabilized in operation, and which is capable of controlling an ejecting pressure and speed of the ink to improve printing quality and printing speed.

Additional aims and advantages of embodiments of the invention will be set forth in part in the description wich follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

According to an aspect of the invention, there is provided an apparatus for jetting ink, comprising: a magnet for generating a first magnetic field; a deformable plate spaced apart from said magnet; a plurality of coils associated with the deformable plate, to generate a second magnetic field in response to an electric signal; an ink chamber for storing ink; and a nozzle communicating with the ink chamber; wherein the deformable plate deforms due to the first and second magnetic fields when the electrical signal is applied between the deformable plate and the magnet, to control a gap between the deformable plate and the magnet.

Preferably, a gap control member is interposed between the deformable plate and the magnet, to control a gap between the deformable plate and the magnet.

Preferably, a nozzle plate is provided spaced apart from the deformable plate, to define the ink chamber in cooperation with the deformable plate, the nozzle being formed in the nozzle plate.

A repulsion may be exercised between the coils and the magnet in response to the electric signal being applied to the coils.

Alternatively, an attraction may be exerted between the coils and the magnet in response to the electric sig-

nal being applied to the coils.

The coils are preferably coated with an insulating material, to prevent the coils from electrical and chemical reactions with the ink.

The ink chamber may be formed between the deformable plate and the magnet, and the nozzle formed in the deformable plate.

The ink chamber may be formed between the deformable plate and the magnet, and the nozzle formed between the magnet and the deformable plate.

According to a second aspect of the invention, an apparatus for jetting ink based upon an electric signal is provided, comprising: a magnet to generate a first magnetic field; a deformable plate positioned to a side of said magnet; a plurality of coils connected to the deformable plate, to generate a second magnetic field in response to an electric signal; and an ink chamber having a nozzle; wherein an interaction between the first and second magnetic fields causes a deformation in said deformable plate, to contract said ink chamber, thereby ejecting ink through said nozzle.

Said deformable plate is preferably elastically deformable and returns to a stable position when no current flows through the plurality of coils.

Said magnet preferably has a magnetic pole, and said deformable plate is opposite to the magnetic pole.

Said magnet is preferably a permanent magnet which forms the first magnetic field to be uniform across a surface of said deformable plate.

Said plate may be made of a polymer and a ceramic.

Preferably, said plurality of coils are connected to a first side of said plate, and said magnet is positioned to a second side of said plate opposite the first side, the apparatus further comprising: gap control members to create a gap between said magnet and said plate; a protecting layer formed on the first side of said deformable plate and covering said plurality of coils; passage walls extending from said protecting layer; and a nozzle plate including said nozzle and connected to said passage walls; wherein said protecting layer, passage walls and nozzle plate form said ink chamber, said protecting layer preventing chemical and electrical reactions between said plurality of coils and the ink.

Said interaction between the first and second magnetic fields may be a repulsive force.

Said magnet may be an electromagnet which forms the first magnetic field to be uniform across a surface of said plate.

Said plurality of coils may be connected to a first side of said plate, and said magnet positioned to a second side of said plate opposite the first side, the apparatus preferably further comprising: passage walls extending from said second side of said plate to said magnet; and wherein said magnet, passage walls, and plate form said ink chamber, and said nozzle is formed in said plate.

A protecting layer may be provided formed on the first side of said plate and covering said plurality of coils, said protecting layer preventing chemical and electrical reactions between said plurality of coils and the ink.

Said plurality of coils may be connected to a first side of said plate, and said magnet positioned to a second side of said plate opposite the first side, the apparatus preferably further comprising: passage walls extending from said magnet to said plate; wherein said magnet, passage walls and plate form said ink chamber, and said nozzle is formed between said magnet and said plate.

Said interaction between the first and second magnetic fields may be an attractive force.

The deformation of said plate preferably varies in accordance with an intensity of the electric signal.

According to a third aspect of the invention, there is provided an apparatus for jetting ink based upon an electric signal, comprising: a magnet to generate a first magnetic field; a plate positioned to a side of said magnet; and an electromagnetic unit to generate a second magnetic field to interact with the first magnetic field in response to the electric signal, thereby causing said plate to deform and thus jetting the ink.

Said magnet preferably forms the first magnetic field to be uniform across a surface of said plate; and said plate is elastic so as to return to a stable position upon termination of the electric signal to said plurality of coils.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 1 is a sectional view showing a conventional apparatus for jetting ink using a heating system;

Figure 2 is a sectional view showing a conventional apparatus for jetting ink using a piezoelectric system;

Figure 3 is a sectional view showing an apparatus for jetting ink according to a first embodiment of the present invention;

Figure 4 is a sectional view for describing an operation of the apparatus for jetting ink according to the first embodiment of the present invention;

Figure 5 is a sectional view showing the apparatus for jetting ink according to a second embodiment of the present invention; and

Figure 6 is a perspective view showing the apparatus for jetting ink according to a third embodiment of the present invention.

Reference will be now made in detail to the present preferred embodiments of the present invention, exam-

ples of which are illustrated in the accompanying drawings. wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

Figures 3 and 4 illustrate an apparatus 100 for jetting ink according to a first embodiment of the present invention. In the figures, the apparatus 100 for jetting ink according to the first embodiment of the present invention includes a permanent magnet 110 for forming a magnetic field, a thin vibrating plate 120 opposite to a magnetic pole of the permanent magnet 110, and coils 122 installed on the upper portion of the vibrating plate 120. Also, a protecting layer 124 protects the coils 122, and a nozzle plate 130 is formed with a nozzle 132.

The permanent magnet 110 forms a uniform magnetic field across the entire surface of the vibrating plate 120, and may be replaced with an electromagnet instead. The vibrating plate 120 is formed of an elastic body and is spaced apart from the permanent magnet 110 by a predetermined interval by a gap control member 126. The gap control member 126 secures a space between the permanent magnet 110 and the vibrating plate 120 to facilitate the vibration (deformation) of the vibrating plate 120. Here, the vibrating plate 120 is fabricated by a material such as a polymer and a ceramic being a nonconductor by using a technique such as a spin coating, lamination, chemical vapor deposition (CVD) and plasma vapor deposition (PVD).

Passage walls 140, arranged in a regular interval, are interposed between the nozzle 130 and the protecting layer 124. The nozzle plate 130, the protecting layer 124 and the passage walls 140 define a plurality of ink chambers 142 filled with the ink 144. The ink chambers 142 are connected to a reservoir (not shown) to be filled with the ink 144 supplied therefrom, and then sealed by the vibrating plate 120.

The coils 122 form a magnetic field to exercise a repulsion against the permanent magnet 110, and is electrically connected with an external driving signal generator 150. The coils 122 may be made by cylindrically winding an enamel-coated conductor lines, a thin film coating of fine structure using a lithography and a thin film technique, etc. the protecting layer 124 prevents the electrical and an chemical reaction between ink 144 and the thin-film coated coils 122.

In describing an operation of the apparatus 100 for jetting ink constructed as above, the magnetic field is generated as a result of the direction of the current flowing through the coils 122 once an AC or a DC signal as a print signal modulated in accordance with predetermined information is supplied from the driving signal generator 150 to the coils 122.

The magnetic field generated by the coils 122 repulses against the magnetic field produced by the permanent magnet 110 (or an electromagnet if used instead of the permanent magnet 110). Since the permanent magnet 110 is fixed, the coils 122 are deformed to bulge upward together with the vibrating plate 120 as shown in Figure 4 by means of the repulsion occurring between the permanent magnet 110 and the coils 122.

The amount of deformation of the vibrating plate 120 is varied with the intensity of an electric signal (voltage or frequency) applied to the coils 122. Therefore, the electric signal applied to the coils 122 is controlled to be capable of easily regulating the quantity and ejecting speed of the ejecting ink 144.

The ink 144 within the ink chamber 142 is pressed by the deformation of the vibrating plate 120. At this time, ink bubbles 146 are ejected from the ink chamber 142 via the nozzle 132 of the nozzle plate 130. If the electric signal of the coils 122 is cut off under this state, the repulsion is dissipated and the vibrating plate 120 is returned to its original position by its own elasticity.

Figure 5 illustrates an apparatus 200 for jetting ink according to a second embodiment of the present invention. As illustrated, the apparatus 200 for jetting ink according to the second embodiment of the present invention has the nozzle 132 formed into the vibrating plate 120, while eliminating the gap control member 126 and the nozzle plate 130 of the apparatus 100 for jetting ink according to the first embodiment of the present invention.

The apparatus 200 for jetting ink according to the second embodiment of the present invention includes the permanent magnet 110 for generating the magnetic field, the vibrating plate 120 placed at an upper portion of the permanent magnet 110 and the coils 122 installed on the vibrating plate 120 for generating the magnetic field. Also included are the passage walls 140 which are interposed between the permanent magnet 110 and the vibrating plate 120 to define the ink chamber 142.

The magnetic field generated by the permanent magnet 110 and the coils 122 produces attraction, so that the vibrating plate 120 is deformed to bulge downward when the electric signal is applied to the coils 122. The electrical and chemical reaction of the coil 122 with the ink 144 are prevented by the protecting layer 124.

The ink chamber 142, filled with the ink 144, is defined by the permanent magnet 110, the vibrating plate 120 and the passage walls 140. When the electric signal is applied to the coils 122 by the driving signal generator 50 (see Figure 3), the vibrating plate 120 is deformed to bulge downward due to the magnetic field produced by the permanent magnet 110 and the coils 122. At this time, the applied pressure affects the ink chamber 142, to externally eject ink 144 via the nozzle 132.

Figure 6 illustrates an apparatus 300 for jetting ink according to a third embodiment of the present invention. In the apparatus 300 for jetting ink according to the third embodiment of the present invention, one side of the ink chamber 142, enclosed by the permanent magnet 110, the vibrating plate 120 and the passage walls 140, is opened to directly eject the ink therethrough.

As illustrated, the nozzle 132 for ejecting the ink 144 shown in Figures 3 through 5 is defined by the perma-

nent magnet 110, the vibrating plate 120 and the passage walls 140, and is formed between the permanent magnet 110 and the vibrating plate 120.

If the electric signal is applied to a coil 122, an attraction is exerted upon the vibrating plate 120 due to the magnetic field formed by the permanent magnet 110 and the coil 122. At this time, the vibrating plate 120 is deformed to bulge downward, thereby externally ejecting the ink 144 via the nozzle 132.

When the ink is ejected from respective ink chambers, an adjacent ink chamber does not eject ink in apparatus for jetting ink according to embodiments of the present invention. As a result, printing of a high quality is achieved.

Furthermore, the quantity of ejecting ink and the ejecting speed can be easily controlled to enable high-speed printing at a high resolution. Additionally, the apparatus for jetting ink is advantageous for permitting a thin type manufacturing and a simplified manufacturing process, to lower the production cost thereof.

While the present invention has been particularly shown and described with reference to particular embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be effected therein without departing from the scope of the invention as defined by the appended claims.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. An apparatus for jetting ink, comprising:

   a magnet (110) for generating a first magnetic field;

   a deformable plate (120) spaced apart from said magnet (110);

   a plurality of coils (122) associated with the deformable plate (120), to generate a second magnetic field in response to an electric signal;

   an ink chamber (142) for storing ink (144); and

   a nozzle (132) communicating with the ink chamber (142);

   wherein the deformable plate (120) deforms due to the first and second magnetic fields when the electrical signal is applied between the deformable plate (120) and the magnet (110), to control a gap between the deformable plate (120) and the magnet (110).

2. The apparatus for jetting ink as claimed in claim 1, further comprising a gap control member (126) interposed between the deformable plate (120) and the magnet (110), to control a gap between the deformable plate (120) and the magnet (110).

3. The apparatus for jetting ink as claimed in claim 1 or 2, further comprising a nozzle plate (130) spaced apart from the deformable plate (120), to define the ink chamber (142) in cooperation with the deformable plate (120), the nozzle (132) being formed in the nozzle plate (130).

4. The apparatus for jetting ink as claimed in claim 1, 2 or 3, wherein a repulsion is exercised between the coils (122) and the magnet (110) in response to the electric signal being applied to the coils (122).

5. The apparatus for jetting ink as claimed in claim 1, wherein an attraction is exerted between the coils (122) and the magnet (110) in response to the electric signal being applied to the coils (122).

6. The apparatus for jetting ink as claimed in claim 1, 2, 3, 4 or 5, wherein the coils (122) are coated with an insulating material (124), to prevent the coils from electrical and chemical reactions with the ink (142).

7. The apparatus for jetting ink as claimed in claim 5, wherein the ink chamber is formed between the deformable plate (120) and the magnet (110), and the nozzle (132) is formed in the deformable plate (120).

8. The apparatus for jetting ink as claimed in claim 5,

wherein the ink chamber (142) is formed between the deformable plate (120) and the magnet (110), and the nozzle (132) is formed between the magnet (110) and the deformable plate (120).

9. An apparatus for jetting ink based upon an electric signal, comprising:

a magnet (110) to generate a first magnetic field;

a deformable plate (120) positioned to a side of said magnet (110);

a plurality of coils (122) connected to the deformable plate (120), to generate a second magnetic field in response to an electric signal; and

an ink chamber (144) having a nozzle (132);

wherein an interaction between the first and second magnetic fields causes a deformation in said deformable plate (120), to contract said ink chamber (144), thereby ejecting ink (1420 through said nozzle (132).

10. The apparatus as claimed in any of the preceding claims, wherein said deformable plate is elastically deformable and returns to a stable position when no current flows through the plurality of coils (122).

11. The apparatus as claimed in any of the preceding claims, wherein said magnet (110) has a magnetic pole, and said deformable plate (120) is opposite to the magnetic pole.

12. The apparatus as claimed in any of the preceding claims, wherein said magnet (110) is a permanent magnet which forms the first magnetic field to be uniform across a surface of said deformable plate (120).

13. The apparatus as claimed in any of the preceding claims, wherein said plate (120) is made of a polymer and a ceramic.

14. The apparatus as claimed in any of claims 1 to 4 or 9 to 13, wherein said plurality of coils (122) are connected to a first side of said plate (120), and said magnet (110) is positioned to a second side of said plate opposite the first side, the apparatus further comprising:

gap control members (126) to create a gap between said magnet (110) and said plate (120);

a protecting layer (124) formed on the first side of said deformable plate (120) and covering said plurality of coils (122);

passage walls (140) extending from said protecting layer (124); and

a nozzle plate (130) including said nozzle (132) and connected to said passage walls (140);

wherein said protecting layer (124), passage walls (140) and nozzle plate (130) form said ink chamber (144), said protecting layer (124) preventing chemical and electrical reactions between said plurality of coils (122) and the ink (142).

15. The apparatus as claimed in claim 14, wherein said interaction between the first and second magnetic fields is a repulsive force.

16. The apparatus as claimed in claim 14, wherein said magnet is an electromagnet which forms the first magnetic field to be uniform across a surface of said plate.

17. The apparatus as claimed in claim 9, wherein said plurality of coils (122) are connected to a first side of said plate (120), and said magnet (110) is positioned to a second side of said plate (120) opposite the first side, the apparatus further comprising:

passage walls (140) extending from said second side of said plate (120) to said magnet (110); and

wherein said magnet (110), passage walls (140), and plate (120) form said ink chamber (144), and said nozzle (132) is formed in said plate (120).

18. The apparatus as claimed in claim 17, further comprising a protecting layer (124) formed on the first side of said plate (120) and covering said plurality of coils (122), said protecting layer (124) preventing chemical and electrical reactions between said plurality of coils (122) and the ink (142).

19. The apparatus as claimed in any of claims 9 to 13, wherein said plurality of coils (122) are connected to a first side of said plate (120), and said magnet (110) is positioned to a second side of said plate (120) opposite the first side, the apparatus further comprising:

passage walls (140) extending from said magnet (110) to said plate (120);

wherein said magnet (110), passage walls

(140) and plate (120) form said ink chamber (44), and said nozzle (132) is formed between said magnet (110) and said plate (120).

20. The apparatus as claimed in claim 17 or 19, wherein said interaction between the first and second magnetic fields is an attractive force.

21. The apparatus as claimed in any of the preceding claims, wherein the deformation of said plate varies in accordance with an intensity of the electric signal.

22. An apparatus for jetting ink based upon an electric signal, comprising:

a magnet (110) to generate a first magnetic field;

a plate (120) positioned to a side of said magnet (110); and

an electromagnetic unit to generate a second magnetic field to interact with the first magnetic field in response to the electric signal, thereby causing said plate (120) to deform and thus jetting the ink.

23. The apparatus as claimed in claim 22, wherein:

said magnet (110) forms the first magnetic field to be uniform across a surface of said plate (120); and

said plate (120) is elastic so as to return to a stable position upon termination of the electric signal to said plurality of coils (122).

FIG. 1

(PRIOR ART)

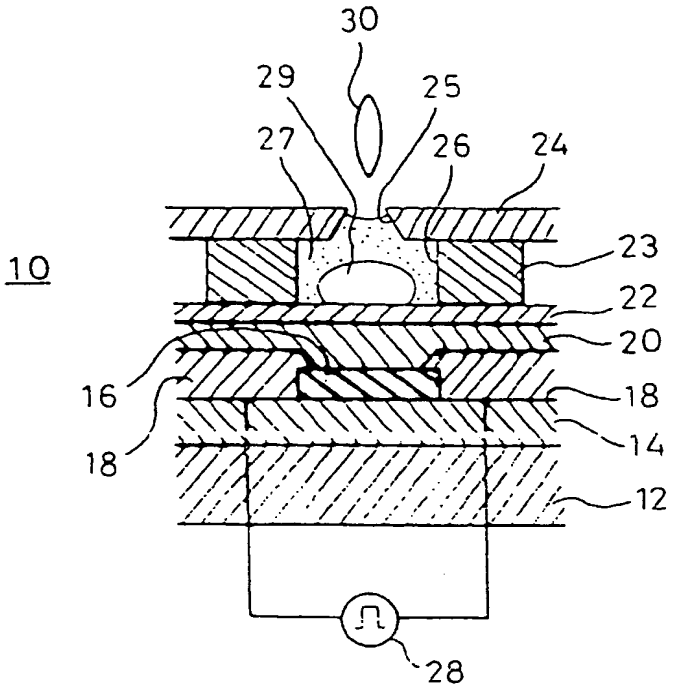


FIG. 2

(PRIOR ART)

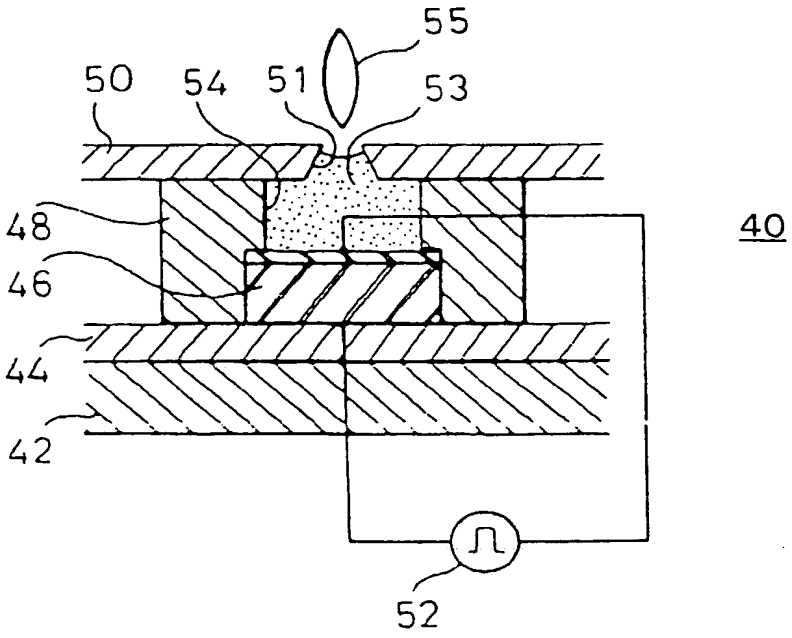


FIG. 3

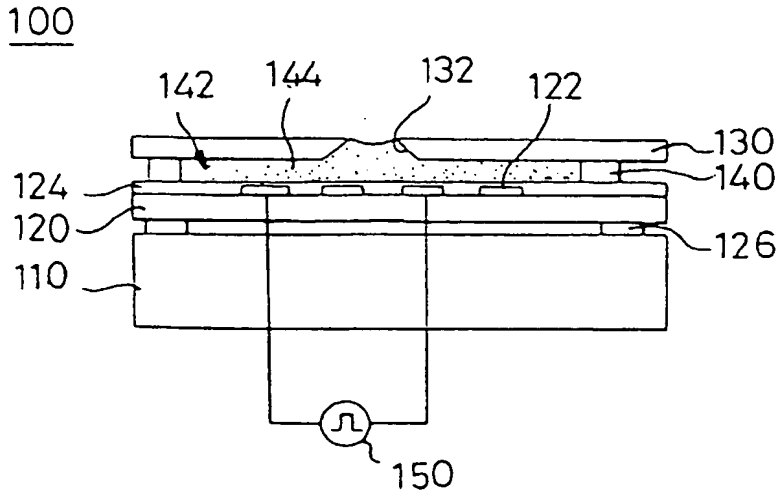


FIG. 4

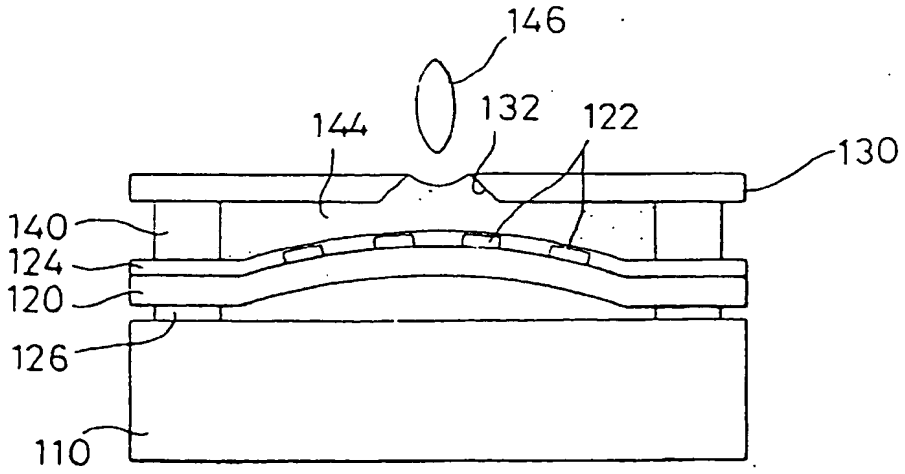


FIG. 5

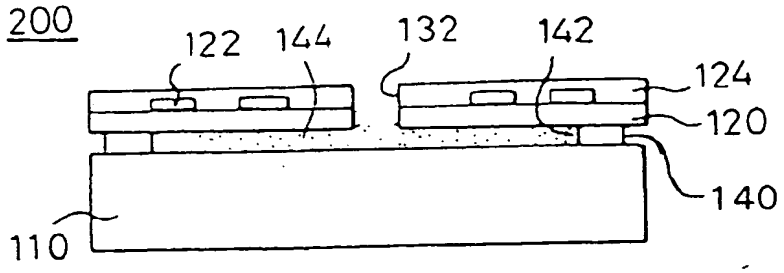
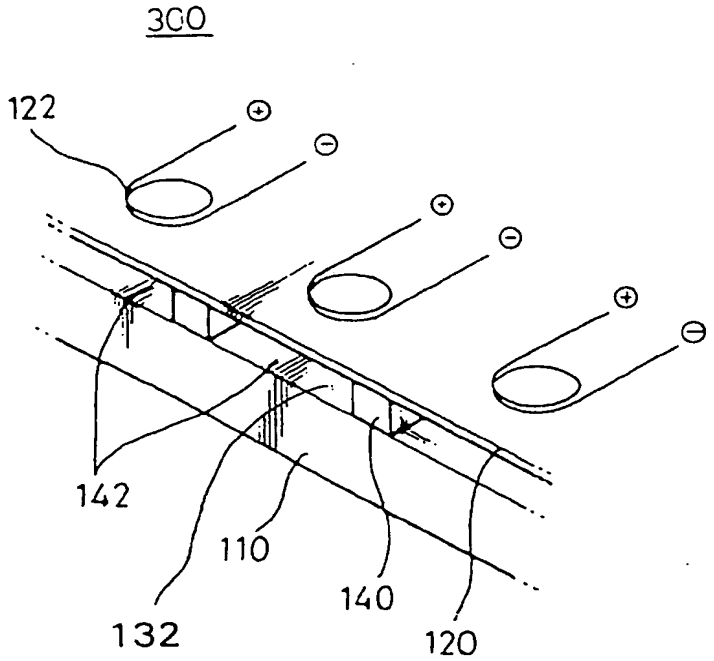


FIG. 6



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(71) Applicant: **Samsung Electronics Co., Ltd.**
Suwon-city, Kyungki-do (KR)

(72) Inventors:
- **Kwon, Oh-keun**
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(74) Representative: **Chugg, David John**
Appleyard Lees,
15 Clare Road
Halifax, West Yorkshire HX1 2HY (GB)

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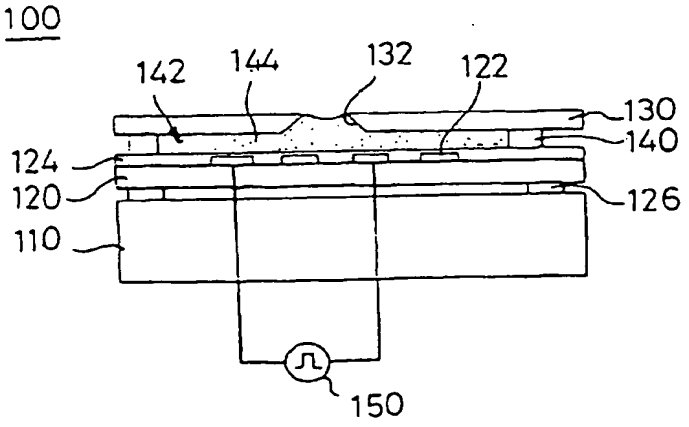
FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 4841

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 4 633 267 A (MEINHOF ANDRE H) 30 December 1986 (1986-12-30) * figures 3,5 * * column 2, line 49 - line 54 * * column 3, line 9 - line 34 *	1,3,4,9, 11,12, 22,23 16	B41J2/045 B41J2/14
X	PATENT ABSTRACTS OF JAPAN vol. 016, no. 391 (M-1298), 19 August 1992 (1992-08-19) & JP 04 129745 A (SEIKO EPSON CORP), 30 April 1992 (1992-04-30) * abstract *	1,3-5,9, 10,22,23	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 4841

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